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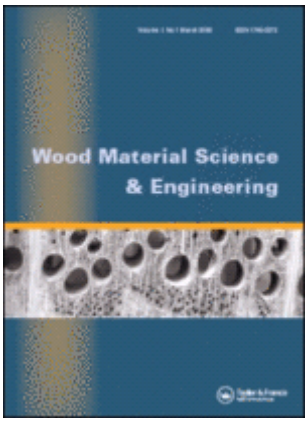

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Institutional and policy frameworks shaping the Wooden Multi-storey Construction markets: A comparative case study on Austria and Finland

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In the urbanizing society faced with the climate change challenge, wood has major potential as a low-carbon and renewable construction material. Yet, Wooden Multi-storey Construction (WMC) remains a niche even in countries with rich forest resources. This paper compares the institutional and policy setting and assesses the WMC growth prospects in Austria and Finland, based on expert interviews, Delphi surveys, and the review of secondary materials. Clear differences were detected in the policy frameworks and institutional settings between the two countries. The Austrian fairly informal and largely private sector driven approaches to promote the growth of the WMC sector seem to have had a rather similar effect on the markets, as the formal policy measures, typically driven by the public sector in Finland. In both countries, the interviewed experts suggested additional, but partly different, policy measures and institutional changes to accelerate WMC market diffusion. In spite of the increase in WMC activity within the past ten years, the WMC market share is likely to remain rather low by 2030 in both countries, as the institutional frameworks are not expected to change abruptly. However, the future market prospects appear to be somewhat more positive in Finland compared with Austria. (198/200 words)

Key words: wood construction, market prospects, path-dependency, policy instruments, institutions

Introduction

In the rapidly urbanizing, increasingly populated and warmer future projected for the globe, wood has potential to increase its share as a carbon neutral, renewable construction material especially in urban, high-rise buildings. Green building[i] has been promoted throughout the EU via several strategies, roadmaps and flagship initiatives, yet without advocating for any special material (Hurmekoski *et al*. 2018). The new bioeconomy strategy of the European Commission of 2018, however, calls for increased use of wood in construction to substitute more energy-intensive materials (EC 2018,

44). In some European contexts, national and local bioeconomy strategies and green building initiatives seek to promote the use of wood in construction (Hurmekoski *et al*. 2018). In addition to the tightening of the environmental regulations nationally and in the EU (Hurmekoski *et al*. 2015b), and the growing public interest towards "sustainable" or green building solutions (Wang et al. 2014), the technological advances over the couple of last decades have paved the way for the increased use of wood in construction (Hildebrant *et al.* 2017).

The development of Engineered Wood Products (EWPs), such as glue laminated timber, laminated veneer lumber (LVL), cross laminated timber (CLT), combined with building concepts based on industrial pre-fabrication, have created opportunities to increase the use of wood in large scale construction, including wood-framed multi-storey construction (e.g. Hurmekoski *et al*. 2015b, Lazarevic *et al*. 2019). In this context, we use the term Wooden Multi-storey Construction (WMC) to refer to a set of innovative construction technologies used for making buildings higher than two floors, where the load bearing structure is for the most part made of wood or wood-based products (Kuittinen 2013, Hurmekoski *et al*. 2018).

However, the markets of WMC are still largely niche markets in Europe, as in most other continents (Hurmekoski *et al*. 2015b, Toppinen *et al*. 2019, Lazarevik *et al*. 2019). Previous studies on WMC diffusion in Europe highlight the strong path-dependencies in the construction sector (e.g. Mahapatra *et al*. 2012, Hemström *et al*. 2017, Toppinen *et al*. 2019), suggesting that institutional lock-ins need to be overcome for WMC to gain a more solid market position (Lazarevik *et al*. 2019). Cost-competitiveness, the fragmented nature of the wood products industry, as well as the isolation of the WMC business projects and actors have been identified amongst the

other key challenges (Riala and Ilola 2014, Antikainen *et al*. 2017, Hurmekoski *et al*. 2018).

This paper seeks to contribute to the knowledge on the market prospects of WMC in two European countries. We approach the topic by exploring the institutional and policy related opportunities for, and barriers to the future growth of WMC in the construction markets, in the case of Austria and Finland. These countries possess rather similar forest resource base, and level of technological development in relation to WMC field, thus providing a promising basis for comparison. In addition, the biggest changes on the WMC markets have occurred within the last decade in both countries. Our key interest is on the characteristics of the policy and institutional frameworks and the types of policy instruments used to advance WMC in the construction markets. We also explore the experts' views on their appropriateness as a means to support future market growth.

This paper addresses the following questions in a comparative setting, identifying and assessing similarities and differences between the countries;

- How have the policy and institutional frameworks related to WMC evolved in these two countries during 1990s-2010s?
- Which policy instruments and promotional measures are currently applied in each country to advance WMC and its diffusion (enabling market growth)?
- Which institutional and policy framework related factors appear as critical for the future market growth of WMC?

In the following sections, we first provide a review on previous research on the dynamics between policies, institutions and WMC markets, and introduce the theoretical background and research methods. Then, we describe the national contexts,

including the characteristics of the wood products industry, the history of wood construction, and WMC markets. Thirdly, we present the results of the analysis. Finally, we discuss the key findings and conclude with a summary of the main differences and similarities in the pathways of the institutional and policy frameworks of WMC, and the future prospects of the WMC sector in Austria and Finland.

Literature review and theoretical framework

Institutional changes have been identified as one of the key factors needed for radical innovations (such as WMC) to replace or alter the established technologies, and to pave way for "creative destruction" in the industry (Vargo and Lusch 2008). Historically, city fires in many European countries influenced the institutional frameworks, e.g. through restrictive building codes. The codes typically rendered the setting more favorable for the use of concrete in multi-storey building, compared with wood (e.g. Mahapatra *et al.* 2012). The shift in the EU policy to move from prescriptive to functional building regulations in the end of 1980s (Mahapatra *et al*. 2012), was reflected in the reforms of the building regulations in many member states (Hurmekoski *et al*. 2015b).

The role of regulatory environment has been emphasized as an important enabler, and a potential barrier, for the development of WMC (Franzini *et al*. 2018, Lindblad and Schauerte 2018, Toppinen *et al*. 2018). Building regulations appear still to be one of the key institutions influencing the market shares of WMC (e.g. Riala and Ilola 2014, Hurmekoski *et al.* 2018, Toppinen *et al*. 2018), even if the recent reforms have made it easier to engage in WMC business in many countries, including Austria and Finland. Lazarevic *et al*. (2019) applied technological innovation system perspective to explore the emergence and evolution of the WMC sector in Finland. They point out that the institutions supporting the dominant construction material in

multi-storey construction have been destabilized, permitting building technologies to compete on a more even playing field (ibid).

On top of shifts in the regulation and changing actor roles, standards appear as an important factor for greater diffusion of WMC. As noted by Mahapatra *et al*. (2012), the lack of codes and standards, for various wood products used in construction, has also been a limiting factor in the institutional context of WMC in the EU. A further limiting factor is that the European CEN[ii]-standards and norms applied for the products in the building sector are very broadly defined and need to hold for all products (Ludvig and Weiss 2013).

Referring to Kadefors (1995), Toppinen *et al.* (2019) suggest that the key types of institutions in the wood construction sector include (governmental) regulation, standardization (of products, systems), roles and interest organizations, which can be considered as external factors. The internal institutional factors include tendering systems, standardized skills and knowledge, as well as learning and routine in the ways professionals operate. The institutional framework thus includes roles and practices, as well as intermediaries that facilitate knowledge diffusion and provide normative guidance for the organizations involved, for example, through lobbying (Vermeulen *et al.* 2007). In addition, it includes governmental regulation, to ensure that the projects are implemented in line with the prevailing building codes and other norms. The standardization (technical infrastructure) acts to ensure that the materials, components, and technologies are applicable with each other independently from selected suppliers in the bidding processes (Dubois and Gadde 2002, Ludvig and Weiss 2013). Effective innovation support depends on appropriate regulatory frameworks just as much as on the financial support of R&D, networking, information sharing and an entrepreneurial attitude within the private sector.

The implementation and shifts of public policies, and their interaction with technological change is one of the issues addressed in research on socio-technical transitions. In this line of theorizing, Markard *et al*. (2016) define policy making to include goals, programs, regulations, laws and funding priorities. In addition, a division can be made between technology and innovation policies, which influence the knowledge generation and diffusion, and deployment policies, which shape the formation of markets and upscaling of new systems (ibid). Innovation policies in the forest sector have developed from a traditional focus on technology push via research funding to more systemic measures, such as regional cluster policies (Weiss et al. 2011, Weiss et al. 2017).

Direct and indirect policies can be used to support wood construction and its value chain, from the forests as the resource base to the products and construction processes (Hildebrant *et al*. 2017). Various types of policy instruments, including regulatory, economic/financial and persuasive ones can be used, exclusively or in combination (Bemelmans-Videc *et al*. 1998, Hildebrant *et al*. 2017). Figure 1 below illustrates the types of policy instruments, which may be used to influence the markets, by creating pull and push effects.

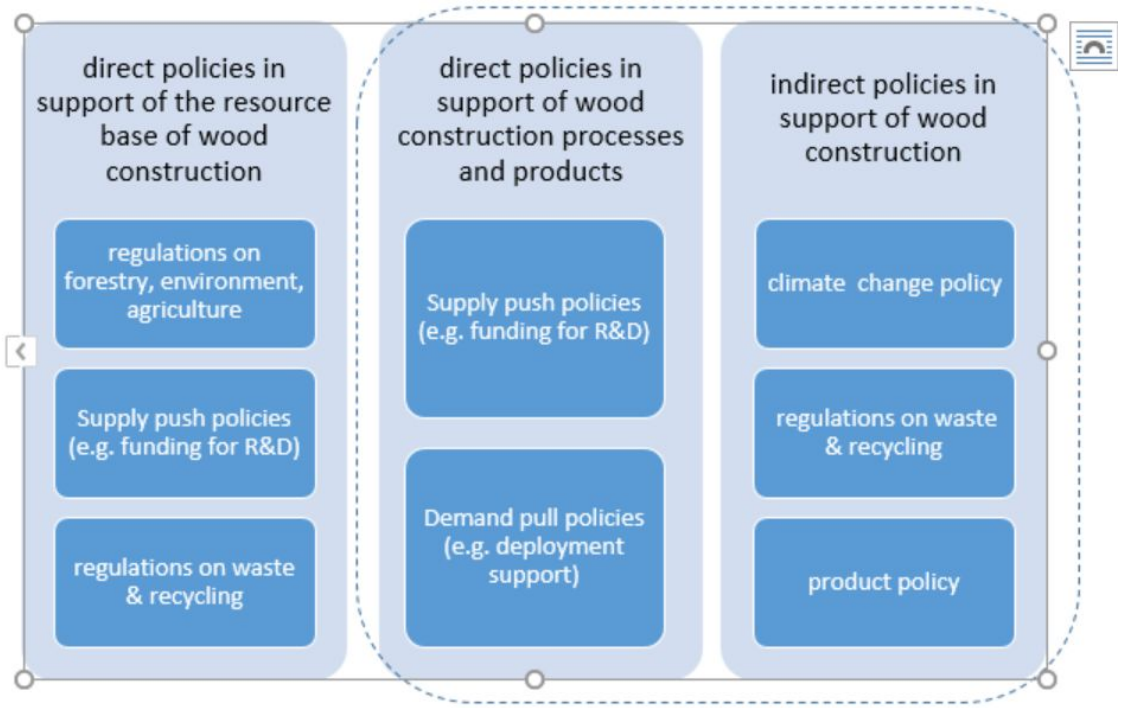

Figure 1. Direct and indirect policies in support of wood construction products and processes. Adapted from Hildebrant *et al*. (2017).

Hurmekoski *et al*. (2018) suggest that greater diffusion of WMC would require more stringent regulatory push, in addition to the changes required in the actor roles in the value chain (e.g. wood element suppliers to take up new roles). Furthermore, they identify two alternative policy orientations for the public sector to influence the uptake of environmentally sound building practices (Hurmekoski *et al.* 2018), including WMC. The first one includes revising the regulatory hindrances and cost burdens and providing a coherent framework for producing information for the markets to stimulate competition. The second one consists of introducing a 'polluter pays' principle by internalizing the externalities of construction on the environment and supporting technologies with smaller environmental footprints. As the building industry, institutions and market conditions tend to vary considerably geographically,

comparative case studies can shed light on whether these types of policy approaches appear realistic in different national contexts, and why.

Methodology and materials

Approach

In our analysis, we draw from the theorizing discussed in the previous section. Our focus is on the external institutional factors, which we understand to constitute the institutional framework. We consider regulations and laws as central parts of the institutional framework, along with standardization and the efforts by the interest organizations. In addition, in our analysis we use the term 'policy frameworks' to refer to public (or semi-public) policy goals, programs, instruments, such as funding priorities and support mechanisms. In our analysis of the policy framework, we focus on direct and indirect policies being used to support wood construction (marked with the dashed line in Figure 1).

The methods of this study consisted of qualitative semi-structured expert interviews (Creswell 1998), which included open-ended questions and using an interview guide. In addition, document and literature analysis (Flick 2006) as well as Delphi surveys (Linstone and Turoff 1975a) were conducted in both countries. In Austria, focus group interviews were conducted as well.

Expert interviews

The purpose of the expert interviews was the collection of information on the present institutional and policy frameworks, and the experts' perspectives regarding possibilities, needs and possible policy gaps for an increase in WMC. In Finland, 16 interviews were conducted in 2018 with experts representing public, third sector and

private sector organizations (Table 1). The criteria to choose the informants were that they had expertise in wood construction and its value chain, or sustainable construction, and that they were (or had been) involved in promotional efforts to support wood/other materials. These experts were mostly from organizations with interest to advance the use of wood, except for one who was associated with sustainable construction, and one associated with more established construction industry. Several of the interviewees had been involved in local WMC related initiatives as well, such as R&D projects.

In the Austrian case, 25 individual interviews and six focus group discussion rounds were conducted between 2017 and 2019 with experts representing companies, wood products/forest industry lobby organizations and national policy makers/actors specialized in bioeconomy, forestry and wood products, construction and climate change issues, at national and capital city level.

Methods of analysis including Delphi-processes and other data sources

The interview data was analyzed by using qualitative content analysis (Mayring 2000), e.g. searching for common themes in the data related to the key research questions, and categorizing these into groups (Mayring 2014). In the analysis, we paid attention on (i) the institutional barriers/opportunities perceived as important, (ii) policy instruments and promotional approaches used so far, and (iii) the policy instruments seen as focal for the future development and market growth of WMC (e.g. Della Porta and Keating 2008, Mair 2008).

Methods	**Austria**	**Finland**
Individual interviews	25 interviews with experts and scientists representing business, lobby groups,	16 thematic interviews with experts representing governmental agencies

	policy makers and policy actors Time frame: spring 2017-spring 2019	(national and regional level policy makers and specialists), business and third sector actors (advocacy, research and expert organizations) Time frame: April-September 2018
Delphi	two rounds of Delphi, incl. open and closed-ended questions Time frame; 2017-2018, visioning towards 2030	Three rounds of Delphi, including open and closed-ended questions (18, 17 and 16 experts, respectively participants) Time frame: 2016-17, visioning towards 2030
Focus groups	6 focus group discussions with experts and scientists representing business, lobby groups, policy makers and policy actors taking place in May and October 2018.	NA
Secondary data	research literature, policy documents (within 2010-	research literature, policy documents (within 2010-

	2019) related to bioeconomy, climate change, forests & wood products	2019) related to bioeconomy, climate change, forests & wood products

Table 1. Research methods used in each country.

The Delphi process provided data for the estimation on the potential (and ideal) future pathways of wooden multi-storey construction. The method is most often used for scenarios and relies on experts who can moderate their feedback throughout the process (Linstone and Turoff 1975b, Green 2014, Hurmekoski *et al*. 2018, Toppinen *et al*. 2018). In our study, the panelists involved were of Finnish, Swedish and Austrian origin, and were required to have in-depth knowledge in the field of wood construction. Time scale in both Delphi studies was up to the year 2030, which is also a target year of many international policy agendas related to bioeconomy and construction, including a European-wide goal for reaching a 30% rise in wood construction (Forest Sector Technology Platform 2012).

In Finland, the Delphi survey data collection took place between 2016 and 2017, in connection with the FORESCOF research project. The number of experts in the Delphi was 18 in the first round, 17 in the second round and 16 in the third round. The first round was conducted through interviews, and the second one through an on-line survey, and the third one through interviews. This study relies on the outputs from the third round of the Delphi study, and the interviews of the Finnish (n=11) experts who participated in that round. In the third round, the interviewees prioritized the most important internal and external factors influencing WMC competitiveness (see also Toppinen *et al*. 2019).

In Austria, the Delphi study was conducted with ten experts between September 2017 and February 2018. This survey included questions on the estimated relevance of WMC as a construction technology, use of wood or wood based products in retrofitting, and the future importance of WMC in the views of the experts. The survey was conducted in the form of a questionnaire in three rounds. In the second round, the experts could comment on the statements of the others. They could also change their own statements, whilst in the third round they could only change their own based on the statements of the others, from the second round. The experts represented organizations in wood industry, building industry and forestry, with experience in wood construction. In addition, scientists, forest owners and representatives of an environmental non-governmental organization in the field of forestry participated.

Whilst the expert interviews collected information mostly on the state of the art and the institutional and policy frameworks of WMC, the Delphi focused on the future prospects. It provided a means to gather opinions in the most anonymous way, with the focus on the content and not the individuals and the performance. This is the advantage of Delphi in comparison, for instance, to group interviews, where mutual influence can bias the results. We believe that it would not be possible to gain sufficient in-depth understanding of the future of the WMC without performing multiple Delphi rounds, which went deeper and deeper into inquiry. It also enabled recognizing possible weak signals and alternative voices.

In addition, policy documents and strategies with relevance for future development of WMC as a construction technology and its market diffusion were identified, based on literature, internet searches, the suggestions made by the interviewees. These were reviewed, in order to identify additional policy measures (used/presently in use) and to crosscheck other data. The secondary data also included

previous research on the markets, as well as policy and institutional aspects of WMC, and future scenarios. The future prospects of WMC in the two countries were constructed based on our analysis of the institutional and policy settings, enriched with the expert views (Delphi), and the insights gained from previous literature on the possible future pathways of WMC development.

Wood products industry, construction and WMC markets in Austria and Finland

As case study countries, Finland and Austria provide fruitful settings to compare the historical development and analyse experts' views of the market growth prospects of WMC, as they share many similarities in terms of the natural resources base and the forest products industry. Within the EU, Finland and Austria are both among the high forest cover countries: Finland with 73% is the highest while Austria with 47% ranges in the upper middle range (Forest Europe 2015). The two countries have high national interest towards the development of wood products industry. Furthermore, they both have long traditions of building with wood. However, the use of wood in urban multi-storey buildings has been rare until recently, e.g. due to the former restrictions, similar to many other countries (c.f. Mahapatra *et al.* 2012).

Both countries are net importers of round wood and net exporters of sawn wood (FAO 2016, EOS 2017, Vaahtera *et al*. 2018). Forestry sector and forest products industry form a central element of the economy in both countries (e.g. Kalt 2015). The wood products industry suffered from long economic recession in Finland in the early years of the 2010s (Mattila *et al*. 2016), but there is again growth in the more recent years (Sipiläinen 2018). In Austria, wood industry has experienced a more steady growth (Neubauer 2009). In both countries, the support of wood industry clusters and

regional cluster-like policies have had an important role in fostering industry development (Rimmler *et al*. 2011).

In terms of the production of EWPs Austria is more advanced in terms of the production capacity compared with Finland. Austria has played an important role in the development of EWPs as well. For instance, modern CLT was developed through a collaborative research effort between industry and academia in the 1990s (Kitek Kuzman *et al*. 2017). Presently, Austria is the largest producer of glulam in Europe, at about 1.5 million m3 per year (2015). With Germany and Switzerland, it also produced 70% of the CLT globally in 2018 (FAO 2018). In Finland, two CLT factories have started the production within the past five years and the third one is being established (Heino 2019). In addition, LVL and glulam is produced in Finland.

There is a long tradition of wood construction in Austria, but the trend has been mainly declining during the past hundred years. Kalcher *et al.* (2017, 146) note that the volume of timber in buildings constructed during the "Wilhelminian time" (about 1848–1918) is assessed to have been significantly larger than in the more recent buildings. Literature also describes low use of timber in the 1950s and 1960s and some increase by the 1970s (ibid). There is also regional variation, e.g. Vorarlberg, located in the western part of Austria, is considered as a "wood-based" region, with long traditions in wood construction (Nord 2008, Kollar 2014), while Styria is a typical example of a more recent cluster policy to support endogenous regional development (Rimmler *et al.* 2011).

In Finland, bricks have historically been the main material used in the load-bearing structures of multi-storey buildings, dominating from the 18th century up to the 1950s (Huuhka and Lahdensivu 2016). Since then, concrete frames became common in the high-rise buildings. Precast concrete elements became a dominant way of building

multi-storey buildings during the 1970s (ibid). Wood-frames have dominated in single-family houses for centuries. Nearly 90 % of the single-family building projects started had wood as structural material in 2017 (Sipiläinen 2018). Yet, the long economic downturn from 2008 to 2016 led to a significant overall reduction in construction activity, which particularly affected the construction of single-family houses. Consequently, the use of wood in construction, in terms of absolute volumes, has decreased significantly.

In Austria, Teischinger *et al*. (2015) estimated that the share of timber buildings[iii] of all residential buildings, measured in terms of built volume, rose from 9% in 1998 to 21% in 2013. This estimation is based on a survey conducted in selected municipalities in six provinces, and the extrapolation of the results to the national level. The share of wooden residential buildings designed for more than one household (multi-family buildings) is still only 2% of the number of residential buildings, and 19% of the built volume of residential buildings (Teischinger *et al*. 2015). In another study, it was estimated that timber buildings with more than two stories made up less than 5% of the building markets in Austria in 2011 (Fadai *et al*. 2014). In spite of the recent high growth rate in the use of wood in buildings, the share of WMC appears to remain low in Austria (e.g. Hurmekoski *et al*. 2015b).

Previous future-oriented research by Kalcher *et al*. (2017) suggest that there will be a clear increase in the use of wood in the building stock in Austria. They estimate that there is currently a volume of approximately 32 M m^3 timber stored in the Austrian residential buildings, and that the stock will increase to over 50 M m^3 until the year 2100, even in the business as usual scenario (Kalcher *et al*. 2017). Their scenario is yet without a specification on the type of buildings so it includes use of wood in all types of buildings and retrofitting.

During the past few years, there has been high growth in the Finnish construction sector, especially in urban areas and multi-storey buildings. The pace of growth in the general construction market has yet been better than in the WMC field. In the residential building sector, the year-to-year growth rate of WMC flats started in 2017 was 6%, compared with 23% of all the flats started in 2017 (Official Statistics of Finland 2018). However, within the past ten years, there has been gradual, but still slow increase in the number of flats in WMC started annually. In 2017, the share of the new flats in wood-framed multi-storey buildings[iv] was five percent of the new flats in multi-storey buildings (e.g. Sipiläinen 2018). In Finland, the actual number of completed residential buildings and office buildings classified as WMCs was 77 and four, respectively, in early 2019 (Wood Info Ltd 2019).

Results

The shifts in the policy and institutional frameworks in Finland

Public strategies for promoting industrial wood construction have been implemented in Finland since the 1990s, which have materialized into R&D projects and technology platforms, as well as information sharing campaigns (e.g. Hurmekoski *et al*. 2015a), creating opportunities for WMC technologies to develop. The first modern WMC buildings were constructed at the end of the 1990s in three geographically scattered regions of the country (Heino 2019). The experiences gained in these pilot projects backed up the reform of the building regulations.

In 1997, the regulations on fire safety were changed to allow the use of wood in the frames for residential and office buildings with the maximum of four floors (without special permits). This change again led to a number of development projects, e.g. testing new building solutions in pilot projects (Tykkä *et al.* 2010). Wood-based construction

experienced an intense development between 2005 and 2015 (Ruuska and Häkkinen 2016), partly mirroring the strongly shifting policy agenda on increasing the use of wood in construction. There was public financial support to a cluster on wood products and forestry industry in the late 2000s and early 2010s, which further supported the technological development of WMC (senior expert at a government agency, personal communication, 31 Aug 2018).

The next important regulative reform and a trigger for the development of WMC came out in 2011. Since then, the regulations have allowed the construction of WMC buildings up to eight stories high. Finally, since the beginning of 2018, the building code allows wooden surfaces to be left partly uncovered (with fire-safety panels) also in the interiors of the WMC buildings.

Wood construction has also been high in the policy agenda of the Finnish bioeconomy strategy, coordinated by the Ministry of Economic Affairs and Employment (MEEA 2014). It is also included in the National Energy & Climate Strategy (NECS) for 2030 (MEEA 2017). The NECS states, "the storage of carbon bound in the Finnish forests will be increased by promoting the use of timber in construction…" (MEEA 2017).

During the government acting between 2015 and 2019, the main initiative to support wood construction, including WMC, was coordinated by the Ministry of Environment, housing and energy (ME). The National Wood Building Program (NWBP) formed a part of one of the priority projects of the government (*bioeconomy and clean solutions*) since 2016. It aimed at increased use of wood in urban construction, in the public sector as well as in infrastructure. The program set 10% annual growth in the number of flats built in WMC buildings as one of its goal (An advisor at ME, personal communication, 16 Apr 2018). Furthermore, in the nexus of

climate and construction policies, ME has produced a roadmap to reduce GHG emissions originating from the construction sector, including the manufacturing of building materials. The goal of this policy process on low-carbon construction is to integrate the carbon footprint into the building regulations by 2025.

In the past few years, the Finnish national level policies have been supplemented with commitments from the municipalities, especially by the six largest cities. The central government has also provided some support for the cities in their strategy work, as well (An advisor at ME, personal communication, 16 Apr 2018). Since 2017, the mayors and directors of six of the largest cities in Finland have committed themselves to increase the use of wood in construction as a means to tackle climate change and strive for sustainability. This commitment was made in the context of the so-called "six cities' climate network", supported also by the Ministry of Environment, housing and energy.

The shifts in the policy and institutional frameworks in Austria

The building regulations in Austria are issued by nine federal provinces (*Bundesländers*), so there is variation in the institutional frameworks of WMC between the provinces. The capital, Vienna, has a special status within the Austrian political system: It ranges on the one hand as "city" and at the same time as *Bundesland* (a federal province) with its own building regulations. The harmonization of regulations in construction is undertaken by the Austrian Institute for Construction Engineering (OIB), which is the official nation-wide technical approval body. For instance, they specify general "protection aims" for all buildings - these are not defined specifically for wooden buildings. One reason for the generality in the approach of OIB is the premise of the neutrality of products, meaning that the OIB has no specific regulations for any single materials.

Revisions during the 1990s in the regional building regulations made it possible to use wood and wood products in the structures of residential housing up to three storeys (Nord 2008). In a way similar to Finland, the first modern wooden multi-storey buildings in Austria were built in the 1990s, having the maximum of three floors (Kaufmann *et al*. 2017, 11). In 2001, the technical requirements in Vienna were changed, resulting in the possibility of wooden construction up to four floors (Novotny 2015, 18). The first registered wooden building with four floors was finalized in 2005 in Vienna (Kaufmann *et al*. 2017, 11).

The eight-storey tall Life Cycle Tower 1 in Vorarlberg in the west of Austria, which was completed in 2012, was another key project for the development of the WMC sector in the country. In this hybrid construction, combining wood and concrete in its structures, research on fire resistance was undertaken (Kollar 2014, Novotny 2015). This development resulted in the last amendment in the regional building regulations from 2015, allowing six-storey buildings without further restrictions in entire Austria (Novotny 2015). The most recent milestone is the 24-storey skyscraper HoHo in Vienna, expected to be finalised in 2019 (Buchner 2018). In this hybrid skyscraper constructed of wood and concrete, the most important goal for the investors and designers of the building was to be the first in finding solutions to the fire protection aims and "even better" ones to meet the OIB protection aims (Principal Architect of the project, personal communication, autumn 2017).

In terms of the policy setting of WMC, the Austrian bioeconomy strategy of 2018 on "Research, Technology and Innovation", does not explicitly address the use of wood in construction, or suggest it among the measures to build up a future bioeconomy (Bioökonomie-FTI-Strategie für Österreich 2018). However, in light of climate change adaptation, efforts towards ecological considerations have increased on a national level.

They have gained momentum via the Austrian climate protection initiative "*klimaaktiv*" that aims to introduce and promote climate friendly technologies and services. It is embedded in the federal climate strategy, fostering market transformation towards energy efficient products and services.

Hitting into this vein, more particularly, the *klimaaktiv* building standard is now the guiding principle for environmental and energy-efficient design throughout Austria. As all building standards (like LEEDs, Bream, DAAD, see Ludvig and Weiss 2013), the standard is implemented on a volunteer ground. However, several buildings have been assessed via the klimaaktiv standard. They allow for comparison along sustainability dimensions, bridging the current state of knowledge, practical applications and the legal framework.

The new Austrian bioeconomy strategy, launched in March 2019, includes a section on construction, with a list of actions to be taken in the field of timber construction and materials (Bundesministerium für Nachhaltigkeit und Tourismus 2019, p. 57):

1) Expansion of regional raw material logistics
2) Empowering employees through improved training opportunities
3) Supporting digitalization along the entire value chain
4) Improving management of residuals
5) Expanding the logistics of primary, intermediate and finished products
6) Harmonizing laws and standards e.g. in construction.

These actions are not directly “fostering” the construction sector in the sense of strategically enhancing wooden construction but rather they aim at improving the conditions for opportunities and support for training, digitalization and logistics. The

chapter on construction in the strategy is accompanied by a picture that illustrates an office in the HoHo building. As the whole strategy has very few visual elements, it is interesting that the building is used for the representation of the topic "construction in the bioeconomy" in Austria. Direct support for wood construction was yet in the agenda of the Austrian wood building charter, signed by 8000 stakeholders, private companies, one minister and several Members of the Austrian national parliament (Wald in Österreich - Das Portal zu Wald und Holz 2019).

Policy instruments and promotional approaches in Finland

At the national level, the key direct policy instruments to promote WMC development and market growth includes supply push policies and persuasive instruments, such as funding to R&D projects (e.g. competitive funding provided under the National Wood Building Program of the Ministry of Environment, housing and energy). Support to education in the field of wood construction, i.e. complementary training of wood working industry and construction professionals, as well as updating education curriculums, appear as other instrument of the same type. Furthermore, policy instruments targeting the demand-pull have been used recently by the public and private sector, e.g. persuasive instruments in the form of information sharing, targeting different stakeholder groups.

In spite of the official policy focus on wood construction, the public sector provided education on wood construction and wood technology seems very limited in Finland, as a recent review study suggests (Federation of the Finnish Wood Working Industries and TTS 2019). There are only two universities of applied sciences providing a study program on wood construction (structural design), and no university level programs. There is one university of applied sciences offering a program on wood technology, and no university programs on it (ibid). According to Antikainen *et al*.

(2017), also inadequate resources to wood material research have posed challenges to the development of WMC. However, the third sector actors (e.g. foundations) channel some funding to university level education and R&D, partly filling in the gap.

An important financial instrument, which can be characterized as a demand-pull instrument, has been the issuing of subsidized loans to the "socially beneficial" WMC projects implemented. This has taken place through the Housing Finance and Development Centre of Finland (known as ARA in Finnish), as most of the WMC projects completed have benefited from the use of this instrument (senior expert at a government agency, personal communication, 31 Aug 2018). Yet, some representatives of the WMC industry stated that the loan conditions did not differ much from other, more "regular" subsidized projects. They expressed that much more could have been done by this agency to advance the WMC growth, if there had been stronger governmental steering. However, more direct governmental steering has occurred recently through a state-owned company, named A-Kruunu Oy (Ltd). Importantly, the construction development company, A-Kruunu, has set a target that 15% of the new flats started in 2021 will be in wooden multi-storey buildings (A-Kruunu 2019).

The national government has also supported the cities policy strategies related to wood construction. At the local level, even before the climate network of the six largest cities committed to expand wood construction in 2017, municipal policy instruments and political support have had a key role in the initiation of new WMC projects. Among the municipal level policy instruments to promote WMC, zoning (especially in the bigger cities), design competitions for buildings targeting special groups, plot assignment stipulations which require the use of wood, and subsidizing the use of wood through pilot projects, appear as common.

It should be also noted that the third sector actors have had influence in the decision-making on some of the WMC projects in the Finnish municipalities. For example, some foundations or other funding agencies have presumed that their funding of a certain building, e.g. a student house, is conditional to the choice of wood as the structural material. Thus, other actors than the municipal decision-makers may be rather strong, even if not always immediately visible, in influencing the WMC market development.

Many experts interviewed and taking part in the Delphi study, especially those in the private sector, considered that the regulations still include 'unfair' safety requirements for the WMC, compared with concrete structural building solutions. An important element of the calculus for many companies is probably the fire safety regulations, which require so-called double safety measures in the WMC flats (which increase building costs), compared with those in concrete multi-storey houses. Nevertheless, other experts interviewed considered that the Finnish building regulations had already been relaxed to the level that would enable WMC and other industrial wood construction to become more prominent and competitive in the construction markets, while other issues were more important as limiting factors. For instance, the fact that the building regulations are not interpreted and implemented in a similar way in different cities was seen as one of the challenges by many. It thus appears that there is the need for harmonization in the interpretation of the rules and guidelines.

Policy instruments and promotional approaches in Austria

In Austria, there are no direct commitments at the national or municipal levels to advance WMC. However, there are manifold campaigns and lobbying efforts from the Austrian wood industry and related interest associations. These include "Wood is genius" campaign (proholz Austria 2019a) or a youth campaign "Great stuff" (proholz

Austria 2019b). In addition, there are public R&D investments into academic positions (e.g. three professorships in the universities) as well as rather limited public research funding on wooden construction. Furthermore, proholz Austria has recently organized special trainings on wooden construction for architects.

Example: The city of Vienna

In the city of Vienna, WMC is politically not actively supported through any formal instruments, such as policy strategies or city funded and/or initiated projects. However, there are public calls for tender that explicitly emphasize ecological lightweight construction that is only possible via wooden and hybrid construction technology, where wood is used in combination with other materials (Novotny 2015, 20).

Another example is the program "Smart City Vienna" which includes the requirement for very high-energy standards although not specifically for wooden building materials (Urban Innovation Vienna 2018). This development becomes visible in the Viennese city development project "*Seestadt Aspern*", which is currently finalized in a larger area (a former private airplane field) in the Eastern outskirts of Vienna. Wood was used as construction material there as well, foremost in some office buildings, including the project known as HoHo. In the case of HoHo, there are signs of subtler forms of political support for increased use of wood in urban construction. Although there was no explicit official support for wood construction and the innovation process was largely driven by core actors from the private sector, there was important informal political support for the realisation of the HoHo project from the side of the authorities (Buchner 2018).

Future prospects of WMC growth in Finland

Based on the Delphi conducted in 2016/2017 among the Finnish experts, the use of wood, either in the form of WMC or in the hybrid multi-storey constructions, is likely to become a more common practice in the urban contexts by 2030 compared with its current use. Any exact percentages of the likely market share of WMC (or its growth rate) were not estimated by most of the experts. Instead, in the thematic interviews conducted in 2018, about one third of the experts gave estimates for the market share of WMC in 2030, varying from 10 % to 30 % (compared with the current 5%), reflecting more than doubling of the market share in about ten years compared with the present. In the Delphi, the figures given by the experts ranged from 20% to as high as 50%. Still, the interviewees in Delphi pointed out that the growth expectations included several uncertainties. As one of the participants pondered the future: "…the share of wood construction will likely increase, including multi-storey buildings. Of course, it demands the emergence of truly competitive actors and supply chains that will then start taking over some of the market". The key issues influencing the growth prospects included the development of the price competitiveness of WMC compared with the concrete building industry, and the pace at which more standardized solutions will emerge for WMC and hybrid structures.

The future picture regarding the growing share of WMC in the building markets is supported by a recent study by the Finnish Construction Research Ltd (Rakennustutkimus RTS Oy 2018), based on a survey conducted among the municipalities. It estimates that within the period of 2018-2020 more than 180 WMC projects will be initiated - twice as many as were started before the year 2018 (ibid). This indicates a very high growth rate for WMC in a short time, notwithstanding that the numbers of projects may not fully reflect the actual situation, as there are differences in the number of completed and planned buildings between different sources.

Many of the interviewed experts also argued that policy interventions are still needed to trigger the growth of WMC markets in Finland. The policy instruments suggested to be used included regulatory ones, e.g. pulling the demand for WMC through urban planning (e.g. zoning) and reforming the building regulations. This included both removing of barriers and internalizing environmental externalities. The former is illustrated by the following comment by a representative of wood products industry: "One can hope that in the future, wood as construction material will be at a level playing ground [with other materials], to the extent possible". Addressing environmental, especially the climate impacts of construction materials, in the building regulations was perceived as a promising policy instrument to support the growth of WMC. In the view of several interviewees, the regulation on low-carbon construction and resource-efficiency of construction will potentially have a major impact on how wood will compete with other materials in the future.

The use of economic instruments was also suggested, such as using public procurement as to create demand. Furthermore, additional investments in the education of wood construction and wood material science experts, information sharing (e.g. among different groups in the value chain, consumers), increased support to R&D (e.g. targeted funding to research institutions), were among the key instruments that the interviewees suggested to support the WMC growth.

Future prospects of WMC growth in Austria

In all three rounds of the Austrian Delphi survey in 2018, national experts on bieconomy, biomass, forestry, wood production and climate change considered it unlikely that the WMC segment will increase its share by 2030, even if they saw it as a desirable development. Nearly all of the respondents answered that the share will remain low, and only one of the experts scored the statement with a five (very likely).

The open answers provided by the respondents converged to some extent. For example, there were statements such as: "*There are important lighthouse projects, but in terms of quantity they are only of minor importance (and that will probably remain so*)". Other comments included "*They [WMC] would have high potential because of the large volume required. Because of durability and physical limitations, wooden construction will not become the most important segment*". Both of these comments suggest that not much will move, albeit for different limitations and constraints. Another statement was yet more positive: "*Greater numbers will increase confidence and knowledge about multi-storey wood construction*". However, a significant increase in the WMC sector is unlikely to occur by 2030, since the WMC markets are not growing rapidly currently, based on the interviews conducted during this study.

In the Austrian Delphi survey, the respondents were also asked which policy measures they deemed relevant to enhancing the decarbonization of the atmosphere through wooden products. On the open question "*Where do you see the biggest chances for a contribution of the Austrian wood industry towards decarbonization*?" ten respondents answered with a mix of several options. Those of the responses that specifically touched upon measures to support wooden construction are summarized below. Two of the suggested support measures concerned the product level:

1) Additional efforts to communicate the material substitution benefits of wood;
2) Developing the recycling of wood, e.g. buildings needing "from cradle to cradle" certificates.

Others emphasized the need for regional policy measures:

3) Regional subventions for wood construction, in a similar way as there is funding for solar or photovoltaic;

4) Public procurement to foster scaling-up wooden solutions.

Finally, there were responses that called for national policy measures:

5) Political support for wooden "lighthouse" projects;
6) The harmonization of building regulations, as the situation is not yet ideal [due to the emphasis on "product neutrality", remark by authors].

Discussion

The governmental innovation policy instruments have played an important role in the development of the WMC technology in Finland, especially during the early stages, in the 1990s and in the first decade of the 21st century, as suggested also in other studies (e.g. Lazarevic *et al*. 2019). The shifts in the institutional framework, especially the gradual removals of the regulatory obstacles on wood-based structural solutions in multi-storey buildings, appear as key factors backing up the evolvement of the new technologies.

In relation to the instruments to propel the WMC market growth (diffusion), urban and land use planning, including zoning and pilot projects have been among the main ones at the city level in Finland. At the national level, subsidized loans, information sharing and awareness raising by both the government and private sector, as well as investments in R&D have been among the key instruments applied. In the recent years, actors within the third sector have also taken a more prominent role in financing R&D and providing funding for WMC construction projects. Regarding the market development (and diffusion of the technology), there is a growth trend in the market share of WMC in the past ten years. However, WMC still represents a niche market, characterized by few companies involved in the business networks.

In Austria, a key difference in the institutional framework of WMC compared with Finland is the more prominent role for the provinces as the regulating authorities in the building sector. In the Austrian case, another major difference is that the policy framework of WMC sets more emphasis on market driven means, compared with Finland. There has been much less formal, government or other public sector led direct policy support for WMC over the last ten years. The policy support for WMC and the increased use of wood in construction in more general has mainly come from the private sector and semi-public organizations, e.g. in the forms of awareness raising campaigns and lobbying. The case of the HoHo project in Vienna, however, indicates that the city authorities of Vienna have had a focal role in enabling the use of wood in an innovative way in a high-rise building although wood construction as such is not backed up by the government, in national, regional (federal) or city level.

In both countries, the changes in the building regulations (especially fire safety) have gradually removed barriers to wood construction, thus creating space for WMC technologies. However, some clear differences were also detected in the institutional frameworks in the two countries. They included, among others, more authority held by the regional administration (federal governments) regarding the building codes, less heavy fire safety regulation (e.g. no double safety measures), smaller maximum number of storeys allowed (without special arrangements/measures) in Austria compared with Finland. Yet, in terms of the development of the WMC market share, the countries seem to be more or less at the same level, based on the literature available (e.g. statistics, previous studies).

Regarding the policy frameworks, the more informal policy approaches in Austria seem to have succeeded in bringing about similar growth as the more formal,

and more often government led or supported policy strategies and instruments in Finland.

The results of the Delphi studies yet indicate that the future prospects for WMC markets are perceived more positively in Finland compared with Austria. Altogether, the Delphi experts foresaw only a rather modest growth of WMC in both countries and the finding was supported by the institutional analysis. More specific and extensive policy support for WMC was perceived necessary by the experts – but it was not foreseen, except for some bigger cities in Finland, which have taken a more proactive role. The results indicate that more comprehensive policy frameworks for regulatory, cost and informational conditions, suggested as the pre-condition for a significant growth in WMC markets by Hurmekoski *et al*. (2018), are not in sight at the national level in our case study countries. Regarding the other policy option suggested by Hurmekoski *et al*. (2018) to enable the growth in the markets of WMC, significant policies for the internalization of environmental externalities, such policies are unlikely to be issued in Austria, whereas in the case of Finland, the carbon footprint of construction will likely be introduced within a few years' time. Depending on how the policy will be formulated in more detail, it may help to accelerate the growth of WMC.

It is notable that from the comprehensive policy framework as presented by Hildebrant *et al*. (2017), only a few of the available, potential instruments are currently being utilized. Measures are mostly restricted to informational and persuasive means such as research, training, information campaigns or certification systems whereas stronger regulatory framework or use of economic instruments are not foreseen, except for some cities in Finland.

Acknowledging that the construction markets are shaped considerably by other factors than policy and institutional frameworks, our research enabled us to form an

improved understanding about the characteristics of the institutional and policy frameworks, and their recent changes, and potential role in shaping the future of WMC diffusion in the two countries studied. We also identified factors related to the institutional and policy frameworks likely to influence the future prospects of WMC in these countries.

One of the limitations of our work was related to the fact that the studies conducted in the two countries were not initially designed as a part of a single research project. This contributed to some differences in the methods used and data gathered between the cases, e.g. how the questions were formulated in more detail, and the types of actors interviewed. Yet, we found sufficient amount of similarities in the approaches, questions and types of data collected to enable the comparison of the two cases. Another challenge was that statistical data regarding the construction markets and use of wood in multi-storey buildings was limited. In addition, one needs to take into account that the experts who participated in the Delphi studies had backgrounds mostly related to wood products industry, forest industry, and wood construction, so the responses might have turned out rather different if we had targeted experts working more closely with other materials, e.g. concrete or steel. Notwithstanding these limitations, the research produced new insights on how the institutional and policy frameworks have evolved in the two countries, and helped to identify opportunities and challenges related to different policy approaches to support the diffusion of WMC.

It will remain an issue for further studies to identify the policy instruments and approaches best suited for varying local and regional institutional and market contexts. As noted by Hemström *et al*. (2017) as well as by Hurmekoski *et al.* (2018), the high autonomy of construction projects and wide regional variations in construction and housing markets, policies and technical specializations mean that the change prospects

of the construction sector may vary much even across a country. These issues deserve further research, involving wider geographic coverage, more cases as well as city/municipality level analysis, for enabling a more comprehensive comparison.

Conclusions

The two case countries share some similarities in the development of the institutional frameworks of WMC, especially the gradual removal of regulatory barriers since the end of the 1990s, even if the details of the building regulations have some differences. Experimental pilot projects have had an important role in informing the gradual processes of regulatory changes in both countries. The main differences detected in the institutional settings between the countries included the stricter fire safety requirements in Finland, fewer number of stores allowed in Austria (without special arrangements), and the stronger role of the regional governments in the WMC regulation in Austria (meaning possibly higher variation among the regions). In addition, the standardization of some of the WMC materials and methods is an on-going process in both countries.

The information available for the two countries suggests that the market shares of WMC are at a rather similar and low level. The Austrian informal, and typically private sector and semi-public organization driven approaches to promote the growth of the WMC seem to have had similar effects on the markets, as the policy instruments typically applied by the public sector in Finland. In the Finnish case, the role of the third sector (e.g. foundations) seems to have increased its importance in recent years, especially in channeling funding to R&D.

In Finland, an important difference in the policy framework compared with Austria is the existence of the national program promoting wood construction. The common policy instruments used to support WMC included persuasive ones, including information sharing and R&D funding, as well as regulatory ones, including land use

planning (zoning), as well as financial instruments, such as procurement and the subsidised loans. In Austria, persuasive instruments by the private sector, such as lobbying and information sharing, have appeared as the key instruments. In relation to the public sector-led approaches, support to R&D and education appears to have been more significant in Austria compared with Finland.

In both countries, the experts interviewed suggested additional, partly similar, partly different, policy measures and institutional changes to accelerate market growth towards the future. In both countries, information sharing (e.g. better communication of the benefits of building with wood or hybrid structures) was one the instruments suggested, and supported widely. In addition, regulatory means, such as reform of the building code (to better address the environmental impacts of buildings and construction) were considered as potentially effective in both cases. In Finland, the regulatory instruments in the form of zoning and the financial instruments, such as subsidies, were viewed more positively than in Austria, even if some experts had concerns especially on these types of measures. In the latter case, they raised more concerns about the public acceptability.

In the light of this study, the future growth prospects of the WMC markets in the time scale of 2030 appear to be more positive in Finland compared with Austria, when it comes to the role of policy and institutional frameworks and their implementation. This is mainly because of the more supportive policy framework in Finland that is operational at several levels and the stronger interest in and active use of the policy instruments directed to support WMC in many of the largest cities.

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[i] Various definitions exist for green building. The common elements include the application of life cycle perspective, considering environmental sustainability aspects, health issues and impacts on the community (Zhuo and Zao 2014).

[ii] CEN refers to The European Committee for Standardization.

[iii] Timber buildings refers to buildings in which more than 50% of the load bearing structure is made of wood or wood-based materials (based on Stingl et al. 2001).

[iv] These figures include the flats in multi-storey buildings with only two floors, so the definition of WMC differs from the one we provided earlier, based on e.g. Hurmekoski et al. (2018).

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